Research Article

DETERMINANTS OF UPPER EXTREMITY FUNCTIONALITY BEFORE ADJUVANT RADIOTHERAPY IN PATIENTS WITH BREAST CANCER SURGERY: A CROSS-SECTIONAL OBSERVATIONAL STUDY

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Abstract

Aim: Comprehensive surgeries lead to decreased shoulder mobility and muscle strength in the upper extremity in patients with breast cancer. Post-operative pain and pain-related kinesiophobia also cause functional impairments. This study aimed was to investigate the relationship between shoulder mobility, muscle strength, pain, and kinesiophobia with upper extremity functionality after breast cancer surgery.

Method: This cross-sectional study involved 89 patients undergoing axillary lymph node dissection within the first 6 months after breast cancer surgery. Shoulder range of motion (ROM) was evaluate using a digital goniometer, muscle strength with a manual dynamometer, functionality via the Disabilities of the Arm Shoulder and Hand (DASH) scale. The Tampa Kinesiophobia Scale (TKS) and Visual Analog Scale (VAS) were used to assess kinesophobia and pain intensity.

Findings: In multivariable regression models, increased degree of shoulder abduction (β±SE=0.20 ± 0.09, p=0.028), and internal rotation muscle strength (β±SE=4.62± 1.51, p=0.003), were important independent predictors of shoulder functionality. Increased kinesiophobia (β±SE=0.69± 0.28, p=0.016), and pain level (β±SE=2.90±0.68, p=0.000) were significantly associated with upper extremity disability. DASH score was negatively correlated with shoulder flexion (r=0.3), abduction (r=0.4), and internal rotation (r=0.3) ROM and shoulder internal rotation muscle strength (r=0.4), but positively correlated with TKS score (r=0.4) and VAS (r=0.5).

Results: Increasing shoulder abduction ROM and internal rotation muscle strength seems superior to restoring the decreased upper extremity functionality. Pain is the most restrictive symptom so coping management strategies with pain can be integrated into the rehabilitation programs, and kinesiophobia levels of patients should be considered during the rehabilitation process.

Keywords: Breast cancer, Upper extremity, Functionality, Kinesiophobia, Muscle strength, Pain

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Meme Kanseri Cerrahisi Geçiren Hastalarda Adjuvan Radyoterapi Öncesi Üst Ekstremite Fonksiyonelliğinin Belirleyicileri: Kesitsel Gözlemsel Bir Çalışma

Öz

Amaç: Kapsamlı cerrahiler meme kanserli hastalarda omuz hareketliliğinde ve üst ekstremite kas gücünde azalmaya yol açmaktadır. Ameliyat sonrası ağrı ve ağrıya bağlı kinezyofobi de fonksiyonel bozukluklara neden olmaktadır. Bu çalışmanın amacı meme kanseri cerrahisi sonrası omuz hareketliliği, kas gücü, ağrı ve kinezyofobinin üst ekstremite fonksiyonelliği ile ilişkisini araştırmaktır.

Yöntem: Bu kesitsel çalışmaya meme kanseri ameliyatından sonraki ilk 6 ay içinde olan aksillar lenf nodu diseksiyonu yapılan 89 hasta dahil edildi. Omuzun normal eklem hareket açıklığı (EHA) dijital gonyometre ile, kas gücü manuel dinamometre ile, fonksiyonellik ise Kol Omuz ve El Sorunları (DASH) ölçeği kullanılarak değerlendirildi. Kinezyofobi düzeyi Tampa Kinezyofobi Ölçeği (TKÖ) ile ve ağrı şiddeti Görsel Analog Skala (GAS) ile değerlendirildi.

Bulgular: Çok değişkenli regresyon modeline göre, omuz abdüksiyon derecesi (β±SE=0.20 ± 0.09, p=0.028) ve iç rotasyon kas kuvvetindeki (β±SE=4.62± 1.51, p=0.003) artış, üst ektremite fonksiyonelliğinin önemli bağımsız belirleyicileriydi. Artmış kinezyofobi (β±SE=0.69± 0.28, p=0.016) ve ağrı düzeyi (β±SE=2.90±0.68, p=0.000) üst ekstremite fonksiyonel yetersizliği ile anlamlı şekilde ilişkiliydi. DASH skoru omuz fleksiyon (r=0.3), abdüksiyon (r=0.4) ve iç rotasyon (r=0.3) EHA ve omuz iç rotasyon kas gücü (r=0.4) ile negatif korelasyon gösterirken, TKS skoru (r=0.4) ve VAS (r=0.5) ile pozitif korelasyon gösterdi.

Sonuç: Omuz abdüksiyon EHA'nın ve iç rotasyon kas gücünün artırılması, azalmış üst ekstremite fonksiyonelliğini geri kazanmada daha üstün görünmektedir. Ağrı en kısıtlayıcı semptomdur, bu nedenle ağrı ile başa çıkma stratejileri rehabilitasyon programlarına entegre edilebilir ve rehabilitasyon sürecinde hastaların kinezyofobi düzeyleri göz önünde bulundurulmalıdır.

Anahtar Kelimeler: Meme kanseri, üst ekstremite, fonksiyonellik, kinezyofobi, kas kuvveti, ağrı

1.INTRODUCTION

Breast cancer is the most frequently diagnosed malignancy among women and one of the three most common cancers worldwide, with lung and colon cancer. One in 8-10 women may develop breast cancer in their lifetime (Torre et al., 2015:87). Breast cancer incidence and mortality are age-related, and more than half of cases among women are aged 50 and over. In addition, 95% of newly diagnosed cases are aged 40 and over (Coughlin, 2019:9; Kushi et al., 2012:30). In Turkey, the incidence of breast cancer has risen 2 times in the last two decades (Özmen et al., 2019:141). Despite the increasing incidence, death rates from breast cancer have decreased in North America and the European Community, which can be attributed to early detection, and systemic and multidisciplinary treatment approaches. The 5-year survival rate in patients with breast cancer has been reported to be nearly 90% (Giaquinto et al., 2022:524; Howlader et al., 2014).

Surgery, radiation treatments, and chemotherapy prolong survival lifespan but also lead to functional impairment of the upper extremities. Extensive treatments such as mastectomy, axillary lymph node dissection, and axillary radiation cause an increased risk of upper limb morbidity (Hayes et al., 2012:2237). Decline in upper limb function compared to pre-cancer level persists up to 6 years after diagnosis (Feiten et al., 2014:537). Limitations in activities and activity participation are critical for patients, and upper extremity disability can cause severe activity restrictions and declined quality of life in the early postoperative period (Harrington et al., 2013:513). Therefore, it is necessary to understand the relationship between the level of impairments and patient-reported outcome measures (Gabel et al., 2009:1; McNeely et al., 2023:1).

Functional performance of the upper extremity is directly related to adequate range of motion (ROM), muscle strength, and pain level. Patients complain of limited active ROM and decreased muscle strength of the shoulder girdle after breast cancer surgery (Fisher et al., 2020:500). In addition, persistent pain is seen in 25-65% of patients and is the primary cause of reduced quality of life (Hidding et al., 201496748). Pain is associated with some risk factors such as type of surgery, anxiety, depression and kinesiophobia (Lancaster et al., 2016:1). Breast-conserving surgeries cause less extensive comorbidities compared to total mastectomy and axillary lymph node dissection, but it has been reported that postoperative pain-related kinesiophobia decreases the physical activity level of patients and leads to secondary comorbidities in breast conserving surgery (Malchrowicz-Mośko et al., 2023:1010315). To our knowledge, there are limited studies in the literature that explore the projection of patient-reported levels of upper limb functionality. The aim of this study was to investigate the effect size of muscle strength, ROM, pain and kinesiophobia on shoulder functionality of patients in the early postoperative period after breast cancer surgery and to determine their relationship with functionality.

2.METHODS

The study was carried out with the permission of the Acıbadem University Non Interventional Clinical Researchers Ethics Committee (ATADEK 2023/17 Decision No: 2023-17/597). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki.

2.1. Participants and study design

This cross-sectional study was conducted Prof Dr Cemil Taşçıoğlu City Hospital, Department of radiation oncology. All participants were informed about the study and their written permission was provided before the participation.

Out of 89 patients who underwent breast conserving surgery or total mastectomy were recruited to the study. Patients were included if they had no radiotherapy, had axillar lenf node dissection, were aged 18 years and older and had no neck, shoulder, or upper extremity disability before the surgery. Patients who had breast cancer surgery in the affected or contralateral side previously, active or metastatic cancer, and a history of neurologic and orthopedic problems were excluded.

2.2. Outcome measures

All assessments were performed by the same investigator (first author). Patients were asked to rest for one hour before the assessments to avoid the effect of fatigue on the results. Also, patients were asked face-to-face with questionnaires assessing upper extremity functionality and kinesiophobia levels.

2.2.1.Upper extremity functionality

The disability of the arm, shoulder and hand (DASH) questionnaire was used to assess upper extremity functionality (Harrington et al., 2014:153). The DASH includes 30 questions in the disability and symptoms section. Each item is scored on 1 (no difficulty) to 5 (unable) likert and it ranges from 0 to 100, with a higher score indicate worse disability (Dowrick et al., 2005:468).

2.2.2. Arm strength

Shoulder flexion, abduction, and internal and external rotation muscle strength of the patients were performed during the maximal voluntary isometric muscle contraction with a manual dynamometer (J Tech Commender Muscle Tester) according to the reported position. During the test, patients were asked to push their arms with maximum force with maximal isometric muscle contraction which was recorded in kilograms. All measurements were repeated three times at 30-second intervals and the mean of the measurements was recorded (Belmonte et al., 2018:32777).

2.2.3.Range of motion (ROM)

Shoulder active ROM was evaluated in degrees using a digital goniometer (Baseline Digital Absolute+Axis Goniometer). All measurements were performed with the patient in the supine position.

Flexion of the shoulder was assessed with the elbow extended in the supine position. External and internal rotation were assessed while the shoulder and elbow were at 90 abduction and flexion respectively, forearm was at neutral supination and pronation. Each measurement was repeated three times and the average value was recorded (Smoot et al., 2016:639).

2.2.4. Pain intensity

The intensity of the pain was assessed with The Visual Analogue Scale (VAS). The VAS is a reliable scale and consists of a 100 mm line (10 cm). Patients were asked to place a mark on the scale to indicate the level of pain intensity with 0 indicates no pain, and a score of 10 indicates severe pain (Bijur et al., 2001:1153).

2.2.5. Kinesiophobia

Fear of movement was assessed with the Tampa Kinesiophobia Scale (TKS). The TKS includes 17 items and each item is scored on 4 point likert type scale of 1 (strongly disagree) to 4 (strongly agree). The total score ranges from 17 to 68 and cut-off score of TKS is defined as a higher score of 37 points is related to kinesiophobia (Lundberg et al., 2009:495).

2.3. Sample size and statistical analyses

The sample size of the study was determined concerning the upper extremity range of motion value in a study (Min et al., 2023:247). At least 81 participants were found to be necessary for a strength of 0.90 with an alpha level of 0.05. Considering a dropout rate of 10%, a total of 89 subjects were included in the study. Sample size was calculated using the GPower V.3.1.7 (Kiel University, Kiel, Germany) program.

Statistical analysis was performed using the SPSS software program (IBM, SPSS version 25, Chicago, IL, USA). The normal distribution of the data was examined using visual (histogram and probability plots) and analytical (Shapiro–Wilk Test) methods. Mann-Whitney-U or Independent-t-test was used for continuous variables and the chi-squared test for categorical variables. Pearson correlation coefficients were calculated to investigate the relationship between the clinical variables. Correlation coefficients were accepted as moderate for $r > 0.4$ and strong for $r > 0.7$ (Mukaka, 2012:69). Multivariable linear regression was used to analyze the association between the DASH score and the objective (shoulder range of motion and shoulder muscle strength) and subjective (VAS and TKS) outcomes separately. Education, body mass index (BMI), type of chemotherapy, and surgery were added to the parameters correlated to functionality and multiple stepwise linear regression analyses was performed. The statistical significance was set at the 0.05 level.

3. RESULTS

Table 1. Demographic and clinical characteristics of the patients

Variables	**Mean(SD) (n=89)**	**Min-Max (n=89)**
Age(y)	52.39(10.29)	30-80
Height (cm)	1.59(0.06)	1.45-1.78
Body weight (kg)	75.26(12.29)	50-106
BMI (kg/m2)	29.79(5.04)	17.72-43.56
Educational level, n (%)		
Primary and Secondary school	65(73)	
High school	20(22)	
University	4 (5)	
Surgery side n (%)		
Right	39 (%43.8)	
Left	50(%56.2)	
Dominant side n(%)		
Right	83(%93.2)	
Left	6 (%6.8)	
Chemotherapy (%)		
Neoadjuvant chemotherapy	53/89 (%59.6)	
Adjuvant chemotherapy	29/89 (%32.6)	
No chemotherapy	7/89 (%7.9)	
Surgery type (%)		
BCS+ AC	48/89(%53.9)	
Mastectomy +AC	41/89(%46.1)	
Metastasis ratio		
M0	89/89	
VAS for pain (0-10)	5.51(2.72)	0-10
Flexion shoulder, deg	135.09(23.58)	82.20-180
Abduction shoulder, deg	110.37(29.81)	40.80-180
ER shoulder, deg	71.08(15.80)	30.20-90
IR shoulder, deg	78.99(10.19)	50-90
Shoulder flexion (kg)	5.37(0.99)	3.30-8.14
Shoulder abduction (kg)	5.14(1.12)	2.64-8.06
Shoulder ER (kg)	5.80(1.63)	2.64-10
Shoulder IR (kg)	6.28(1.81)	2.56-10.60
DASH	40.95(18.78)	6.77-80.83
TKS	41.93(6.53)	24-59
TKS>37	76/89(%85.3)	
TKS≤37	13/89(%14.7)	

Abbreviations: SD: standart deviation, BMI; body mass index, BSC; Breast Conserving Surgery, AC; Axillary curettage, VAS; visual analogue scale, ER; external rotation, IR; internal rotation, DASH; Disabilities of the Arm, Shoulder and Hand Scale, TKS; Tampa Kinesiophobia Scale.

A total of 109 patients with breast cancer were evaluated and 20 of them met the exclusion criteria. A total of 89 patients were included in the present study. The mean age and weight of the participants were 52.39 and 75.26 respectively. Fifty patients had left side surgery while 39 patients had right side. The majority of the patients (59.6%) had neoadjuvant chemotherapy. Patients' mean pain intensity was found 5.51 and the mean TKS score was higher than cut-off score of TKS. Out of 89 patients, 13

did not have kinesiophobia, while 76 had kinesiophobia according to the TKS cut-off score. Based on this result, 85% of our patients demonstrated the presence of kinesiophobia. Demographic and clinical findings are presented in Table 1. Chi-squared test was used to analyze the dominant side associations based on the operated side and no significant difference was found (p>0.05).

Table 2. Correlation analysis for patients with breast cancer

	DASH score	
	r	**p value**
VAS for pain (0-10)	0.53	**.000**
Flexion shoulder, deg	-0.36	**.000**
Abduction shoulder, deg	-0.49	**.000**
ER shoulder, deg	-0.36	**.000**
IR shoulder, deg	-0.12	.257
Shoulder flexion (kg)	-0.14	.171
Shoulder abduction (kg)	-0.06	.558
Shoulder ER (kg)	-0.29	**.005**
Shoulder IR (kg)	-0.43	**.000**
TKS	0.41	**.000**

Abbreviations: VAS; visual analogue scale, ER; external rotation, IR; internal rotation, DASH; Disabilities of the Arm, Shoulder and Hand Scale, TKS; Tampa Kinesiophobia Scale.
p: Pearson correlation

The DASH scores were negatively correlated with ROM of shoulder flexion (r= -0.36), abduction (r= -0.49) and external rotation (r= -0.36), strength values of shoulder external rotation (r= -0.29) and shoulder internal rotation (r= -0.43). In addition, DASH scores were positively moderately correlated with VAS values (r= 0.53) and TKS scores (r=0.41). Pearson's rank correlation coefficients are displayed in Table 2.

Table 3. Multiple linear regression model for the objective clinical outcome parameters

Independent variables	**B (S.E)**	**ß**	**p-value**
Flexion shoulder, deg	0.06(0.12)	0.08	.610
Abduction shoulder, deg	-0.20(0.09)	-0.32	**.028**
ER shoulder, deg	-0.18(0.14)	-0.16	.209
IR shoulder, deg	0.00(0.18)	0.00	.961
Shoulder flexion (kg)	-1.58(2.74)	-0.08	.566
Shoulder abduction (kg)	2.09(2.49)	0.13	.403
Shoulder ER (kg)	1.87(1.75)	0.16	.418
Shoulder IR (kg)	-4.62(1.51)	-0.47	**.003**

$R^2 = 0.33$, adjusted $R^2 = 0.24$. Dependent variable: Disabilities of the Arm, Shoulder and Hand Scale (DASH), ER; external rotation, IR; internal rotation

According to the results of multiple linear regression model with enter method, patient's DASH score was influenced by the shoulder abduction ROM and internal rotation muscle strength. The model explained 33% ($R^2 = 0.33$) of the variance of the DASH score (Table 3). Also strength of

shoulder internal rotation had the highest significance. Also the model explained that both subjective outcomes were relative with DASH score positively (R^2 = 0.31). The increase in pain intensity and TKS scores caused the high DASH score, thus leading to a decrease in the level of functionality (Table 4).

Table 4. Multiple linear regression model for the subjective clinical outcome parameters

Independent variables	B (S.E)	ß	p-value
VAS for pain (0-10)	2.90(0.68)	0.41	**.000**
TKS	0.69(0.28)	0.24	**.016**

R^2 = 0.31, adjusted R^2 = 0.30. Dependent variable: Disabilities of the Arm, Shoulder and Hand Scale (DASH)
VAS; visual analogue scale, TKS; Tampa Kinesiophobia Scale.

According to Table 2, multiple stepwise linear regression analysis was performed by adding patients' education level, type of chemotherapy, body mass index and type of surgery to the model consisting of shoulder flexion, abduction and external rotation ROM, external and internal rotation muscle strength of shoulder and TKS score, which were related to functionality. The results of multiple stepwise linear regression analysis showed that VAS, muscle strength of the shoulder IR and shoulder abduction ROM were the main influencing factors of the functionality in patients with breast cancer surgery in the early post-operative period (Table 5). There was no relation between the functionality and education level, type of chemotherapy, BMI, and type of surgery.

Table 5. Multiple Linear Regression Analysis: Disabilities of the Arm, Shoulder and Hand Scale (DASH) as dependent variable (n = 89)

Model	Independent variables	R^2	Adjusted R^2	p-value	SE
1	VAS	0.26	0.25	**.000**	16.07
2	VAS and Shoulder IR strength	0.37	0.35	**.000**	14.97
3	VAS, Shoulder IR strength and abduction shoulder ROM	0.42	0.40	**.000**	14.41

VAS; visual analogue scale, IR; internal rotation, ROM: range of motion

4. DISCUSSION

We designed this study to investigate the impact level of shoulder muscle strength, ROM, pain, and kinesiophbia on upper extremity functionality in the early period after breast cancer surgery. Our findings indicated that shoulder abduction degree and internal rotation muscle strength were significantly associated with DASH score according to linear regression analysis. Also pain and TKS were associated with DASH score in the result of the present study.

Having a dominant or non-dominant operated side may affect the objective outcome measurements. It has been reported that the muscles on the dominant side were higher than the non-dominant side in healthy individuals (Pang et al., 2023: 1284959). In our study, we analyzed the dominant side relationship compared to the operated side and found no significant difference. Therefore, dominance does not seem to be a confounding factor that would affect homogeneity of the group and results.

Most upper limb and shoulder disorders are detected within three months after surgery and persist for more than 2 years. Scar tissue, fibrosis, and soft tissue shortening (e.g., pectoral and chest wall muscles) can cause postoperative pain, decreased ROM, and reduced muscle strength during the acute treatment phase (Lacomba et al., 2010:320). These physical limitations have an extensive effect on women's capacity to complete daily activities and their ability to return to work. Physiotherapists usually prescribe shoulder ROM exercises to minimize physical limitations in early rehabilitation programs (Redemski et al., 2022:650). Teodozio et al, reported that patients with breast cancer surgery may perform shoulder flexion and abduction ROM exercise in a free range up to the pain limit until the 30th postoperative day and they also stated that these exercises were safe and led to an increase in functionality (Teodózio et al., 2020:97). Herrington et al stated that shoulder functionality was highly correlated with active shoulder flexion and external rotation ROM (r=0.6) and active ROM indicated 40% of the variance of the scores on the DASH (Harrington et al., 2013:513), but they did not evaluate shoulder abduction degree. According to the result of our study shoulder abduction ROM had higher correlation with DASH score compared to another shoulder ROM, and shoulder mobility defined as 33% of the variance of the scores on the DASH was lower than the literature. This could be as a result of the strength variable being included in our study's regression model. To improve functionality, the degree of shoulder abduction should be specifically considered in patients with breast cancer surgery.

Strengthening programs are beneficial in improving shoulder and arm function in the early and late postoperative periods of breast cancer rehabilitation (De Groef, Van Kampen, et al., 2017:1625). Studies have reported that shoulder girdle strengthening exercises provide significant changes in shoulder flexion, abduction and external rotation muscle strength at the moderate evidence level (Scaffidi et al., 2012:601; Zhou et al., 2019:2156). According to patient- reported outcomes, shoulder function showed less potential for recovery without the intervention applied (Kool et al., 2016:62). Luz et al. investigated the effectiveness of the shoulder strengthening program and found that minimal change in strength was found in internal rotation (Luz et al., 2018:1405). In our study, shoulder functionality was significantly associated with internal rotation muscle strength (B=-4.62). Based on this regression coefficient value, it was observed that a 1-unit increase in internal rotation muscle strength resulted in a 4.62 point decrease in the DASH score. In our study results, the highest regression coefficient value was seen in internal

rotation muscle strength into the objective outcome measurements.".Therefore early implementation of internal rotation muscle strengthening exercises can be beneficial for patients because it is difficult to regain back.

Pain and pain-related disability affect 25-80% of the breast cancer survivor population (Reinertsen et al., 2010:405). Pain negatively impacts the quality of life, increases financial demands on the individual and the health care system, and can lead to reduced activity and participation in daily life. Treatment of chronic pain is indicated to reduce the individual's suffering, optimize quality of life, and return patients to their pre-disease functioning and participation in meaningful life roles such as family and social networks in breast cancer survivors (Muliira et al., 2017:6). Groef et al. identified pain intensity as a potential risk factor for high upper extremity DASH scores up to 1.5 years after breast cancer surgery (De Groef, Meeus, et al., 2017:52). In our results, pain had moderate correlation (r= 0.5) and was highly associated with DASH scores according to the linear regression result (B= 2.9). A one -unit change in pain level leads to a 2.9 point differences in the DASH score.

Kinesiophobia is the fear that movement and physical activity may worsen side effects such as fatigue and pain and it has been identified as a barrier to exercise for people with cancer (Sander et al., 2012:525). Due to increased levels of fear, patients may have to gradually reduce or limit their physical activity levels. This avoidance behavior has been theorized a central role in both pain and chronic fatigue (Jones et al., 2016:51). Mosko et al. reported that a significant value (>37 points) of women with breast cancer experienced kinesiophobia and it is related to pain intensity. In addition, kinesiophobia was found in 30.8% of women with breast cancer in Turkey (Can et al., 2019:139). This rate was reported to be high compared to other countries (Malchrowicz-Mośko et al., 2023:1010315). Altas et al. reported that 70% of breast cancer patients who received radiotherapy had kinesiophobia 1 year after surgery (Altas & Demirdal, 2021:130). In our study, 85% of the women had a score above the cut- off value stated in the literature. Only 13 patients were below 37 points. In line with these results, the percentage of the present study was higher than the literature. Additionally, the patients in our study were in the early postoperative period and had not received radiotherapy. The finding of high rates may be due to these points.

There are some limitations of our study. First, the patients were within 6 months after surgery. Post-operative evaluations could be made by dividing into specific periods such as (0-3), and (3-6). Second, physical activity levels of the patients could also be evaluated. Thus, we could have revealed the influence of kinesiophobia on the activity level of the patients.

5. CONCLUSION

This study provides valuable information related to impact of breast cancer surgery on upper limb function. Shoulder abduction ROM, internal rotation muscle strength, pain, and kinesiophobia were found significantly effective in the restoration of upper limb function after breast cancer surgery. Pain was also detected as one of the most important causes of shoulder dysfunction. Regardless of the type of surgery, and chemotherapy, BMI and educational level of the patients, the rehabilitation goals of the patients should be determined by considering these results due to the functional problems, morbidities and high treatment costs that occur in the chronic period or after radiotherapy.

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Conflict of Interest

There was no conflict of interest.

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